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METHOD AND APPARATUS FOR COUNTING SOMATIC CELLS OR FAT DROPLET IN MILK

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to dairy farming, ar more specifically to methods and apparatuses for countir somatic cells or fat droplets in milk.

DESCRIPTION OF RELATED ART AND BACKGROUND OF THE INVENTION

A major cause of loss in dairy farming is an infection, known a mastitis, which occurs in an animal's udder. Mastitis is cause by contagious pathogens invading the udder and producing toxi that are harmful to the mammary glands. Generally, mastit starts in one udder quarter.

Somatic cells, predominantly white cells and epithelial cell enter the mammary gland as a result of damage to the alveol lining by infection or chemical irritation. The counting somatic cells excreted in the milk has become a widely us measure of mammary gland inflammation. The somatic cells can counted by laborious direct microscopic method on stained mi smears, or the cell numbers can also be estimated by dire chemical tests. Other methods measure milk somatic cel indirectly or by determining the concentration of various b products of the inflammatory response.

Somatic cell count (SCC), which is the number of white cells p milliliter of milk, increases in the bulk tank as mastit spreads in the herd. SCC scores are used as an internatior standard in determining milk's quality and price. Most market organizations and regional authorities regularly measure SCC bulk tank milk and use these scores for penalty deducti

and/or incentive payments. High SCC scores indicate the presenc of mastitis in the herd, which is reflected in the average scor of the bulk tank. The bulk tank SCC is a good indicator o overall udder health and as good means for evaluating th mastitis control program.

It is also a high correlation between the bulk milk SCC and th average of individual animal counts. It is not uncommon for few problem animals to be responsible for greater than 50% o the somatic cells in the bulk tank, particularly in small herds It should be noted that animals with high milk production an intermediate SCC levels can have a significantly highe percentage of SCC contribution to the tank score than some hig SCC cows with low production. For high quality milk the SC should be less than 200,000 cells/ml. Acceptable milk has SC scores from 200,000 to 500,000 cells/ml. For infected animals milk SCC scores are between 600,000 and 1.2 million cells/ml.

When an animal in the herd becomes infected with infectio pathogens a rapid drop in milk production will be noted withi two to three days. A high level of bacteria in an animal cause an increased level of somatic cells in milk. An increased leve of somatic cells in milk results in poorer quality mil products, which are harder to process. The prevention procedure at milking are less efficient especially when the mastitis is i a subclinical phase and there are no visible signs of tl disease. Special efforts have to be made at each milking t detect subclinical mastitis in individual animals.

SCC may be measured by CMT (California Mastitis Test) utilizing the difference in the extent of aggregation reacti depending on the number of somatic cells, when a surfactant added to the milk. Since a BTB reagent is also included for measurement, it is used as an evaluation index for mastitis

utilizing the fact that increased vascular permeability an accelerated conflict between leukocytes and bacteria durin mastitis results in increased salts such as sodium chloride an potassium chloride in the milk, creating a higher alkalinity and causing a color change from yellow to green and then t blue. The advantages of this measurement are that it can b easily performed by anyone, it can generally distinguish betwee the presence and absence of mastitis, and it is an extremel low-cost method. The drawbacks of CMT are that diagnosis i difficult until the reaction has occurred, involving th conflict between leukocytes and the bacteria, or after promotio of vascular permeability, and that diagnosis depends o subjective human judgment, so that this method can only serve a an approximate diagnosis method. Diagnosis has been particularl rough in cases where the milk somatic cell count is 300,000/m or less. The method is thus not suitable to be automated.

Measuring CL (chemiluminescence) activity has also been used fo determining the SCC, see e.g. US Pat. No. 6,297,045. A relate method is to add to the milk a fluorescent additive, which i absorbed by the cells. By illuminating the milk with light of particular wavelength the cells will emit a fluorescent light o another characteristic wavelength. By a suitable filter, whic filters out light of the characteristic wavelength, the numbe of cells can be counted.

Such an approach requires that milk samples are taken, that suitable amount of fluorescent additive has to be added an mixed with the milk, and that particular light sources ar filters are used. This is a labor intense and costly procedure If the method is automated in a milking robot system, particul provisions have to be taken in order to obtain and separa

small amounts of milk, which is representative of the milk fro a cow or an udder of a cow.

Mastitis may alternatively be detected by measuring changes i the electrical conductivity of milk as generally, io concentration, and thus electrical conductivity, in mastiti milk is higher than in normal milk. Electrical conductivity i generally measured with a DC or AC circuit having a prob positioned in the flow of milk. The most sensitive part of thi on-line method is the probe. The probe generally includes tw electrodes to which an AC or DC current is supplied to create a electrical circuit through the milk. The conductivity of th milk is evaluated by measuring the current variations in th circuitry that includes the probe. However, the readings ar often inaccurate due to deposits of colloidal materials from th milk on the electrodes, and also due to polarization Polarization occurs because some of the ions migrating toward the electrodes are not neutralized and consequently, an offset or leakage current is generated between the electrodes. Th presence of the leakage current results in inaccurat conductivity readings. Different aspects on milk conductivit measurements have been patented, see e.g. U.S. Pat. Nos 3,762,371; 5,416,417; 5,302,903; 6,307,362 B1; and 6,378,455 B]

Conductometry has disadvantages in that it depends on change occurring by inflammation reaction after the bacteria invade an conflict with the leukocytes, and therefore it is unsuitable fo diagnosis in the initial stages of mastitis, while it has poo reproducibility due to substantial differences in electroly components and concentrations in different teats or differe cows even with normal milk, such that diagnosis is risky by th diagnostic method alone.

Another potential problem using milk conductivity measurement to discover mastitis is that the conductivity of the milk i heavily dependent on the milking intervals, see *Influence c different milking intervals on electrical conductivity befor alveolar milk ejection in cows*, K. Barth and H. Worstorff Milchwissenschaft 55(7), 2000, p. 363. Thus, the milkir intervals have to be taken into consideration if milking time are not as fixed as in conventional milking systems.

SUMMARY OF THE INVENTION

A general object of the present invention is thus to provide method and an apparatus, respectively, for counting somat cells or fat droplets in milk on-line during milking by automated milking system, which lack the drawbacks a limitations associated with the prior art described above.

A particular object of the invention is to provide such a meth and such an apparatus, which are completely automatic a provide a somatic cell or fat droplet count score.

It is a further object of the invention to provide such method and such an apparatus, which count somatic cells or f droplets directly in a milk line of the automated milki system.

It is yet a further object of the invention to provide such method and such an apparatus, which are capable of providing separate somatic cell count or fat droplet score for each udc quarter of a cow.

It is still a further object of the invention to provide sucl method and such an apparatus, which are reliable, flexible, fairly low cost, and relatively easy to implement.

These objects, among others, are according to the presen invention attained by methods and apparatuses as specified i the appended patent claims.

Further characteristics of the invention, and advantage thereof, will be evident from the following detailed descriptio of preferred embodiments of the present invention give hereinafter and the accompanying Figs. 1-6, which are given b way of illustration only, and thus are not limitative of th present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates schematically, in a perspective view, mai components of a milking robot provided with an apparatus fo counting somatic cells or fat droplets in milk on-line durin milking according to a general embodiment of the presen invention.

Figs. 2-3 illustrates schematically, in cross-sectional top an end views, an apparatus for counting somatic cells or fa droplets in milk on-line according to a particular embodiment o the present invention.

Figs. 4-6 show three examples of two-dimensional digital image as recorded by the apparatus of Figs. 2-3 during counting o somatic cells or fat droplets.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 illustrates some of the main components of a milkin robot. The milking robot comprises four teat cups 11, of whic only one is illustrated for sake of simplicity. Each teat cup 1 is connected to a respective milk tube 13, which in turn i connected to an end unit 15 via a respective valve or regulat

17, a respective milk conduit 18, a respective flow meter 19 and a common milk meter 21. The end unit is connected to · vacuum source (not illustrated) via a milk/air separator and vacuum supply conduit 23.

During milking of the teats of a milking animal, the teat cup are attached to the teats of a cow typically by a robot arm (no illustrated) and vacuum is supplied to the end unit 15 via th vacuum supply conduit 23 to draw milk from the teats of the cow through the milk lines 13 and into the end unit 15. The valve or regulators 17 may be used to control the individual vacuu levels in the teat cups 11. The milk from each udder quarter o the cow is measured individually by the flow meters 19 wherafter the weight of the milk from the cow is measured by th common milk meter 21. Finally, the milk is collected in the en unit 15 and the air is sucked out through the conduit 23.

Further, the milking robot comprises a pump and regulator syste 27 for pumping the milk to e.g. a larger milk storage tank (nc illustrated) via one 29 of a plurality of milk output lines 29 31 connected to the end unit. Another milk output line 31 may b used for discarding milk from the milking of a cow, for pumpir the milk to another tank (not illustrated), or for pumping th milk to a feed device for feeding calves.

The milking robot is advantageously connected to a compute based processing and control device 35, which is responsible fo processing and controlling of the milking robot, and comprise typically a microcomputer, suitable software, and a databa including information of each of the cows milked by the milki robot, such as e.g. when the respective cow was milked la time, when she was fed last time, her milk production, h health, etc.

For the purpose of identifying cows, which have an increased SCC scores, e.g. in order to treat or monitor these cows, or in order to direct the milk from them to not mix it with milk from healthy cows or cows having low SCC scores, the present invention presents an improved technique for counting somatic cells in milk on-line during milking.

An inventive apparatus for counting somatic cells or fat droplets in milk on-line during milking, schematically shown by reference numeral 33 in Fig. 1, comprises generally a flat or shallow measuring chamber, a light source, a two-dimensional camera system including a lens system, preferably a microscope, and a digital image processing system. In Figs. 2-3 is illustrated a particular embodiment of the apparatus in detail, which embodiment will be described further below.

The flat measuring chamber is arranged so that at least a portion of the milk drawn from the teats of a cow, through the milk lines 13, and into the end unit 15 is flowed though the measuring chamber. The light source is set to illuminate milk that flows through the flat measuring chamber, and the two-dimensional camera system is adapted to repeatedly record two-dimensional digital images of the illuminated milk that flows through the flat measuring chamber. The camera array and the lens system are adapted so that a rather small image area is recorded, but with high magnification. A spatial resolution better than about 5 microns in the two-dimensional digital images is preferred. Finally, the digital image processing system is adapted to determine, e.g. by use of neural networks, a somatic cell or fat droplet count score from the two-dimensional images.

Preferably, the digital image processing system is implemented in the processing and control device 35.

The flat measuring chamber may be arranged in a separat conduit, provided for leading away a portion of the milk fro one or several of the milk conduits 18. Optionally, the milk i brought back to the milk conduit(s) 18 or is brought to the en unit 15 after having passed the flat measuring chamber Advantageously, however, the flat measuring chamber is arrange within one of the milk conduits 18.

Such solution is adopted by the particular embodiment of th apparatus as being illustrated in Figs. 2-3. A measuring cel comprises a top and a bottom cell block 37, 39, which whe being attached to each other in a fluid tight manner by mean of four bolts 41 or similar form a milk passageway 43 from lef to right. The passageway 43 has preferably a circular cros section as illustrated. The measuring cell is mounted in one o the milk conduits 18 so that milk flows through the passagewa 43 as indicated by arrows 44. Alternatively the cell blocks 37 39 are designed to form a milk passageway of other cros sectional shape, e.g. quadratic or rectangular.

Further, the bottom cell block 39 of the measuring cell i provided with a substantially vertical through hole 45. Th surface of the bottom cell block 39, which together with corresponding surface of the top cell block 37, form th passageway 43, is shaped to be plane within a major portion c a given area. A light transparent plate 48 fitted within th flat portion is glued to the bottom cell block 39 in a flui tight manner. The position of the plane surface portion of th bottom cell block 39 is selected so that the upper surface c the plate 48 is in level with the lowest portion of the surfac forming the passageway 43 outside of the area. The passagewa surface of the bottom cell block 39 within the given area, bı outside the plane surface portion, may be shaped to obtain

smooth transition to the passageway surface of the bottom cel. block 39 outside the given area. By providing smooth surface within the measuring cell, pockets where milk may b accumulated are avoided. The size of the hole 45 is selecte such that the front portion of a two-dimensional camera syste 51, e.g. CCD-based system, provided with a lens system 49 preferably a microscope, for magnification can be inserted int the hole 45 as illustrated.

The top cell block 37 of the measuring cell is provided with substantially vertical through hole 53, preferably smaller tha the hole 45, and aligned with the hole 45. A rod 55 is fitte to be inserted to the through hole 53 so that a flat er surface 55a of the rod 55 is located in said passageway 4 opposite to and parallel with the plate 48. The rod 55 i tightly fitted in the through hole 53 to prevent milk frc leaking out through the hole 53, and is movable in a verticε direction as is indicated by arrow 57.

The flat measuring chamber 59 is defined as the space betwe the plate 48 and the flat end surface 55a of the rod 55. Thu the flat measuring chamber 59 is open in directions bei parallel with the plate 48 and the surface 55a, and orthogon to a general direction of the flow of milk as indicated by t arrows 44. During SCC measurements the thickness t of t measuring chamber 59, i.e. the dimension of the measuri chamber 59 in a direction parallel with the optical axis 61 the camera system 51 during measurements, is preferably small than about 100 microns, more preferably smaller than about microns, and most preferably smaller than about 10 microns. is important to obtain a depth of field and focusing of t camera system 51 so that the images are sharp; and to red

the probability of cells "hiding" behind an imaged cell. Sucl cells will obviously not be counted.

The rod 55 is preferably light transparent to allow fo: illumination of the milk that flows through the flat measurin chamber 59 by a light source, schematically indicated by 63 through the rod 55. It shall, however be appreciated by the ma skilled in the art that other illumination techniques may b used including i.a. mirror and beamsplitter arrangements. Mil in the flat measuring chamber 59 may be illuminated from abov as illustrated or from below, i.e. from the camera system 5 side. In the latter instance the end surface 55a of the rod 5 may be light reflecting.

In general, light as transmitted trough milk in the measurir chamber is recorded by the camera system. Alternatively c additionally, light as reflected by milk in the measurir chamber is recorded. Further, the orientation of the measurir chamber 59 and the camera system 51 may different from what i illustrated in Figs. 2-3.

The milk is sucked through the lines 18 intermittently and : mixed with air. Thus, it is particularly advantageous to ha the measuring chamber 59 arranged at the very bottom of tl passageway 43 as it is most probable that milk will pa through there due to gravity. In order to assure that milk . not clogged in the measuring chamber 59, the rod may be rotat around the axis 61 continuously during measurements as bei indicated by arrow 65. The rod may be moved vertically and rotated automatically by means of a motor (not illustrate connected to the processing and control device 35.

The camera system 51 is preferably provided with a microsc or tele/macro photo lens system 49 to record strongly magnif:

two-dimensional images. Preferably, the camera system 5 provides for a spatial resolution in the two-dimensiona digital images better than 2 microns, more preferably bette than about 1 micron, and most preferably better than about 0. microns. As a result thereof very small areas are recorded an probably a very large number of images have to be recorded i order to provide accurate and precise SCC scores.

In Figs. 4-6 are illustrated three different two-dimensiona images as recorded by a SCC measuring apparatus according t the principles of the present invention, but set up in laboratory environment.

In the first image (Fig. 4) only fat droplets are visible whereas in the second and third images (Figs. 5-6) severa somatic cells are identified among a large number of fa droplets (the somatic cells are indicated by the arrows). A can be seen in Figs. 5-6 the somatic cells look quite differen than the fat droplets and these differences are used by th digital image processing system to distinguish the differen particles in the images. Generally, the digital imag processing employed includes the analysis of number, size shape, structure, morphological structure, density and/c composition of particles found in each image as revealed by th reflection and/or transmission properties of the particles a found in the images recorded. Preferably, the image processir system uses neural networks.

Using a 600x400 pixel CCD-camera provided with a microscope t record images covering an area of 0.3x0.2 mm^2 the spatia resolution in the images is estimated to be about 0.5 microns Using a measuring chamber with a thickness of about 0.1 mm eac sample volume imaged amounts to $0.6x10^{-6}$ ml. Thus given a SC score of 1 million cells/ml, which may be a typical score fc

an infected cow an average of only 0.6 cells/image will b found in each image. By recording a large number, e.g thousands, of images, and by means of digital image processin of these images a somatic cell count score can be determined.

The somatic cells are in some instances, e.g. when the milk i mastitic, predominantly white cells, and thus the somatic cel count score may be a count score of white cells. In othe instances, e.g. for healthy animals having naturally high SC scores, the number of epithelial cells are higher. In stil other instances, e.g. in case of serious disease or injury, th number of red blood cells may be estimated.

From number and size of fat droplets in the images a content o fat may also be estimated using digital imaging processing.

While the particular embodiment of the SCC measuring apparatu has been described as being mounted in one of the milk conduit 18, and thus measures SCC in a single udder quarter, it may b connected downstream of the point where milk from the udde quarters are mixed. For instance in a milking machine where th teat cups are connected to a single milk line via a cla (upstream of the end unit), the SCC measuring apparatus may b located in this single milk line. However, since mastitis ofte starts in one or maybe two udder quarters, this is not the mos preferred solution as the detection sensitivity for mastitis i reduced when milk from infected udder quarters are mixed wit milk from healthy udder quarters before the SCC measuremen takes place.

The most flexible solution is to have a measuring cell mounte in each one of the milk lines 18 in the robot of Fig. 1, an then to provide one light source and one camera system for eac measuring cell, or to provide a single light source or camer

system which is alternately used for SCC measurement of mil that is flowed through the various measuring cells. Then, th SCC scores for the different udder quarters may be compared t obtain a very sensitive detection of mastitis or increased SC scores in milk from individual udder quarters.

It shall further be appreciated that by implementing the above identified flexible solution a milking robot with four en units – one for each udder quarter, milk could be transporte and taken care of on an udder quarter individual basis, e.g milk from udder quarters having low SCC score is collected i one tank and milk from udder quarters having high SCC score i collected in an other tank.

It shall still further be appreciated by the person skilled i the art that the present invention may be implemented i virtually any kind of automated or semi-automated milkir system.

CLAIMS

1. A method for counting cells or fat droplets in milk on-lin during milking of a milking animal, characterized by the steps of:

- flowing at least a portion of the milk as obtained durin said milking of said milking animal through a measuring chambe (59);

- illuminating milk that flows through said measuring chamber;

- repeatedly recording two-dimensional digital images o illuminated milk that flows through said measuring chamber said two-dimensional digital images being recorded through lens system (49), preferably a microscope; and

- determining a somatic cell or fat droplet count score fro said two-dimensional images by means of digital imag processing.

2. The method of claim 1 wherein said at least a portion of th milk flowed through said measuring chamber (59) is free fro toxic additives.

3. The method of claim 1 wherein said at least a portion of th milk flowed through said measuring chamber (59) is pure natura milk, optionally mixed with air, but free from any chemica additives.

4. The method of any of claims 1-3 wherein said repeatedl recordings of two-dimensional digital images are performed t obtain a spatial resolution better than about 5 microns preferably better than about 2 microns, more preferably bette

than about 1 micron, and most preferably better than about 0.. microns, in said two-dimensional digital images.

5. The method of any of claims 1-4 wherein said measurin chamber has a dimension (t) smaller than about 100 microns preferably smaller than about 50 microns, and more preferabl smaller than about 10 microns, in a direction parallel with th optical axis (61) of said lens system during said repeate recordings.

6. The method of any of claims 1-5 wherein said digital imag processing includes the analysis of number, shape, size structure, density and/or composition of particles found i each image as revealed by the reflection and/or transmissio properties of the particles recorded spatially resolved by sai camera system.

7. The method of any of claims 1-6 wherein said digital imag processing includes the use of neural networks.

8. The method of any of claims 1-7 wherein said at leas portion of said milk, which is flowed through said measurir chamber, is lead away from a milk line (13) of a milkir machine used to collect the milk as obtained during sai milking of said milking animal.

9. The method of claim 8 wherein said at least portion of sai milk, which is lead away from said milk line, is brought bac to said milk line or brought to a milk collecting containe after having been flowed through said measuring chamber.

10. The method of any of claims 1-7 wherein said at leas portion of said milk is flowed through said measuring chamb (59) within a milk line (13) of a milking machine used

collect the milk as obtained during said milking of sai milking animal.

11. The method of any of claims 1-10 wherein said milking o said milking animal is performed by an automated or semi automated milking system, which comprises a plurality of tea cups (11), each of which being connected to a respective mil line (13), which milk lines in turn are connected to container (15) via a claw and a single milk line, wherein during milking of the teats of said milking animal, sai plurality of teat cups are attached to the teats of the milkin animal and vacuum (23) is supplied to said container to dra milk through said milk lines, said claw, said single milk lir and into said container.

12. The method of any of claims 1-10 wherein said milking c said milking animal is performed by an automated or semi automated milking system, which comprises a plurality of tea cups (11), each of which being connected to a respective mi line (13), which milk lines in turn are connected to container (15) wherein, during milking of the teats of sa milking animal, said plurality of teat cups are attached to tl teats of the milking animal and vacuum (23) is supplied to sa container to draw milk through said milk lines and into sa container, wherein said milk is drawn in separate milk lin (13) all the way to said container.

13. The method of any of claims 1-12 wherein said somatic ce or fat droplet count score is a count score of white cells.

14. The method of any of claims 1-13 wherein said container provided with a plurality of milk output lines (29, 31); a said milk drawn through the milk lines and into said contai

is output through one of said plurality of milk output line depending on said somatic cell or fat droplet count score.

15. The method of any of claims 1-14 wherein a content of fa is estimated from said two-dimensional images by means of sai digital imaging processing.

16. The method of claim 15 wherein said content of fat i estimated from number and size of fat droplets in said twc dimensional images.

17. The method of claim 12 wherein

- a measuring chamber (59) is provided in each milk line;

- at least a portion of the milk drawn through the respectiv milk lines is passed through the respective measuring chambers

- milk that flows through the respective measuring chambers i illuminated;

- two-dimensional digital images of illuminated milk that flow through the respective measuring chambers is repeatedl recorded, where said two-dimensional digital images ar recorded through a lens system to obtain a spatial resolutic better than about 5 microns in said two-dimensional digita images; and

- somatic cell or fat droplet count scores for milk draw through the respective milk lines are determined from said twc dimensional images by means of digital image processing.

18. An apparatus for counting somatic cells or fat droplets i milk on-line during milking of a milking animal characterized in:

- a measuring chamber (59), through which the milk as obtaine during said milking of said milking animal is flowed;

- a light source system (63) for illuminating milk that flow through said measuring chamber;

- a two-dimensional camera system (51) including a lens syste (49), preferably a microscope, for repeatedly recording two dimensional digital images of illuminated milk that flow through said measuring chamber, where said two-dimensiona digital images are recorded through said lens system; and

- a digital image processing system (35) for determining somatic cell or fat droplet count score from said two dimensional images.

19. The apparatus of claim 18 wherein said at least a portio of the milk flowed through said measuring chamber (59) is fre from toxic additives.

20. The apparatus of claim 18 wherein said at least a portio of the milk flowed through said measuring chamber (59) is pur milk natural milk, optionally mixed with air, but free from an chemical additives.

21. The apparatus of any of claims 18-20 wherein said twc dimensional camera system provides for a spatial resolution i said two-dimensional digital images better than about microns, preferably better than about 2 microns, mor preferably better than about 1 micron, and most preferabl better than about 0.5 microns.

22. The apparatus of any of claims 18-21 wherein said measurir chamber has a dimension (t) smaller than about 100 microns preferably smaller than about 50 microns, and more preferabl

smaller than about 10 microns, in a direction parallel with tł optical axis (61) of said lens system during said repeate recordings.

23. The apparatus of any of claims 18-22 wherein said digita image processing system is adapted to analyze number, shape size, structure, density and/or composition of particles four in each image as revealed by reflection and/or transmissic properties of the particles as recorded by said camera system.

24. The apparatus of any of claims 18-23 wherein said digita image processing system is adapted to use neural networks i determining said somatic cell or fat droplet count score frc said two-dimensional images.

25. The apparatus of any of claims 18-24 wherein

- said milking of said milking animal is performed by a automated or semi-automated milking system, which comprises plurality of teat cups (11), each of which being connected to respective milk line (13), which milk lines in turn ar connected to a container (15), wherein, during milking of th teats of said milking animal, said plurality of teat cups ar attached to the teats of the milking animal and vacuum (23) i supplied to said container to draw milk through said milk line and into said container; and

- said measuring chamber (59), through which said at leas portion of said milk is flowed, is arranged within one of sai milk lines (13).

26. The apparatus of claim 25 wherein said measuring chamber i defined by a light transparent plate (48) mounted in a wall c said one of said milk lines, through which said two-dimensiona camera system is adapted to record said two-dimensional images

and an oppositely located substantially flat and paralle surface (55a).

27. The apparatus of claim 26 wherein said measuring chamber i open in directions being parallel with said light transparen plate and said substantially flat surface, and orthogonal to general direction of the flow (44) of said at least portion c said milk.

28. The apparatus of claim 26 or 27 wherein said substantiall flat surface is rotatable (65) around an axis being orthogona to said light transparent plate and said substantially fla surface.

29. The apparatus of any of claims 26-28 wherein sai substantially flat surface is an end surface of a rod (55).

30. The apparatus of claim 29 wherein said rod is ligh transparent to allow for illumination through said rod of sai milk that flows through said measuring chamber.

31. The apparatus of any of claims 25-30 wherein said containe is provided with a plurality of milk output lines (29, 31); an said apparatus further comprises a pump and regulator syste (27) connected to said digital image processing system (35) fc pumping said milk drawn through the milk lines and into sai container out through one of said plurality of milk outpu lines depending on said somatic cell or fat droplet coun score.

32. The apparatus of any of claims 25-30 wherein

- each of said milk lines is provided with a measuring chamber through which a portion of the milk drawn through th respective milk line is passed;

- said light source system is adapted to illuminate milk tha flows through each of said measuring chambers;

- said two-dimensional camera system is adapted to repeatedl record two-dimensional digital images of illuminated milk tha flows through each of said measuring chambers; and

- said digital image processing system is adapted to determin a somatic cell or fat droplet count score for milk draw through each of said milk lines from said two-dimensiona images.

33. The apparatus of any of claims 18-24 wherein

- said milking of said milking animal is performed by a automated or semi-automated milking system, which comprises plurality of teat cups (11), each of which being connected to respective milk line (13), wherein, during milking of the teat of said milking animal, said plurality of teat cups a attached to the teats of the milking animal and vacuum (23) i supplied to said teat cups through said milk lines to draw mil through said milk lines;

- each of said milk lines is provided with a measuring chambe through which a portion of the milk drawn through t respective milk line is passed;

- said light source system is adapted to illuminate milk th flows through each of said measuring chambers;

- said two-dimensional camera system is adapted to repeated record two-dimensional digital images of illuminated milk th flows through each of said measuring chambers;

- said digital image processing system is adapted to determi a somatic cell or fat droplet count score for milk dra

through each of said milk lines from said two-dimensiona images; and

- a directing means connected to said digital image processi system for directing milk drawn through each of the respecti milk lines into a selected one of a plurality of containe depending on the respective somatic cell or fat droplet cou score.

34. A milking robot comprising the plurality of teat cups (11) the plurality of milk lines (13), the container (15), and t apparatus for counting somatic cells or fat droplets of any claims 18-33.

ABSTRACT

A method for counting somatic cells or fat droplets in milk on line during milking by an automated or semi-automated milkin system comprising the steps of: flowing milk as milked by th milking system through a measuring chamber (59); illuminatin milk that flows through the measuring chamber; and recordin multiple two-dimensional digital images of illuminated mil that flows through the measuring chamber, wherein the image are recorded through a lens system (49) to preferably obtain spatial resolution better than about 5 microns in the images Finally, a somatic cell or fat droplet count score of the mil is determined from the images by means of digital imag processing, preferably including the use of neural networks.

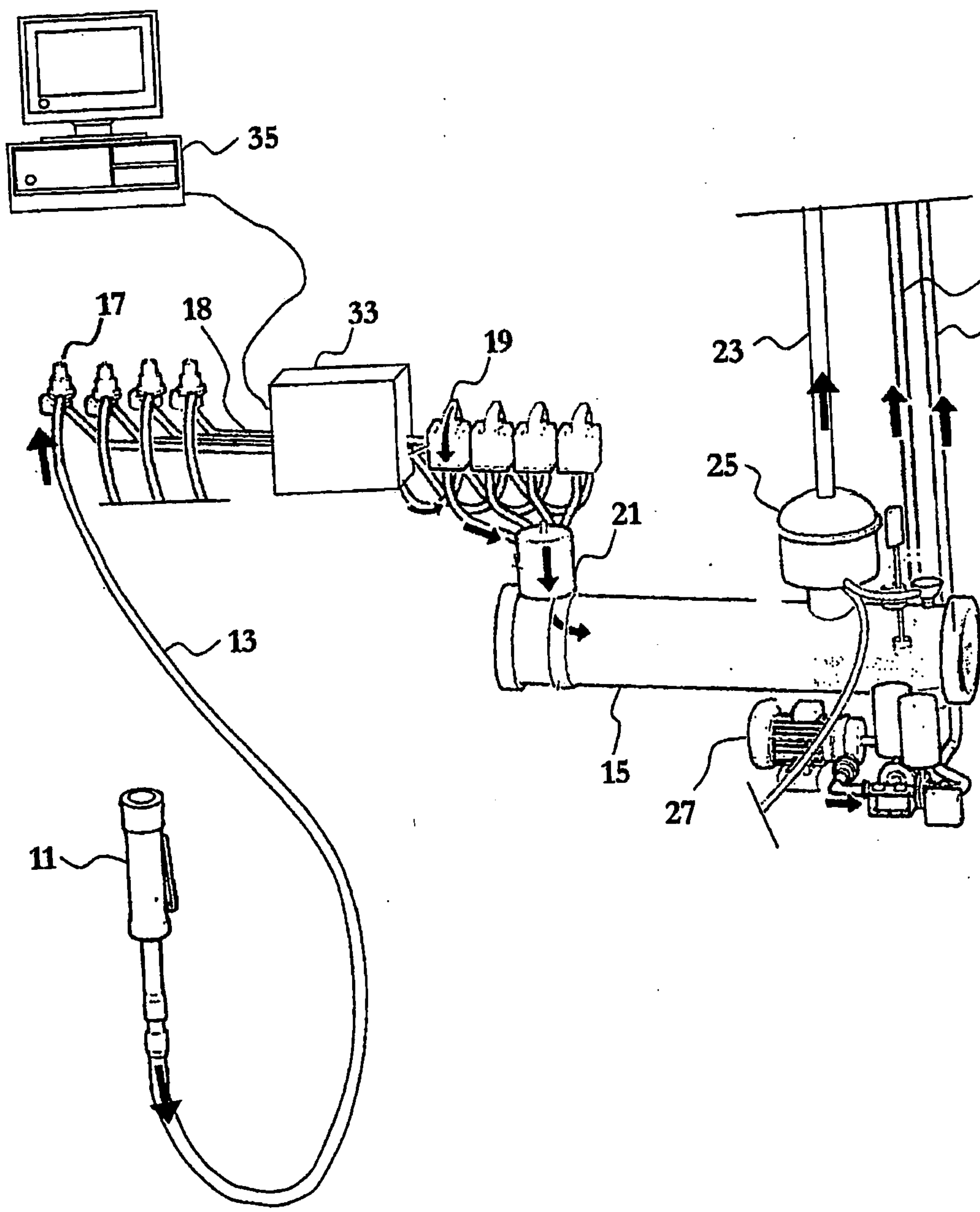

Fig. 1

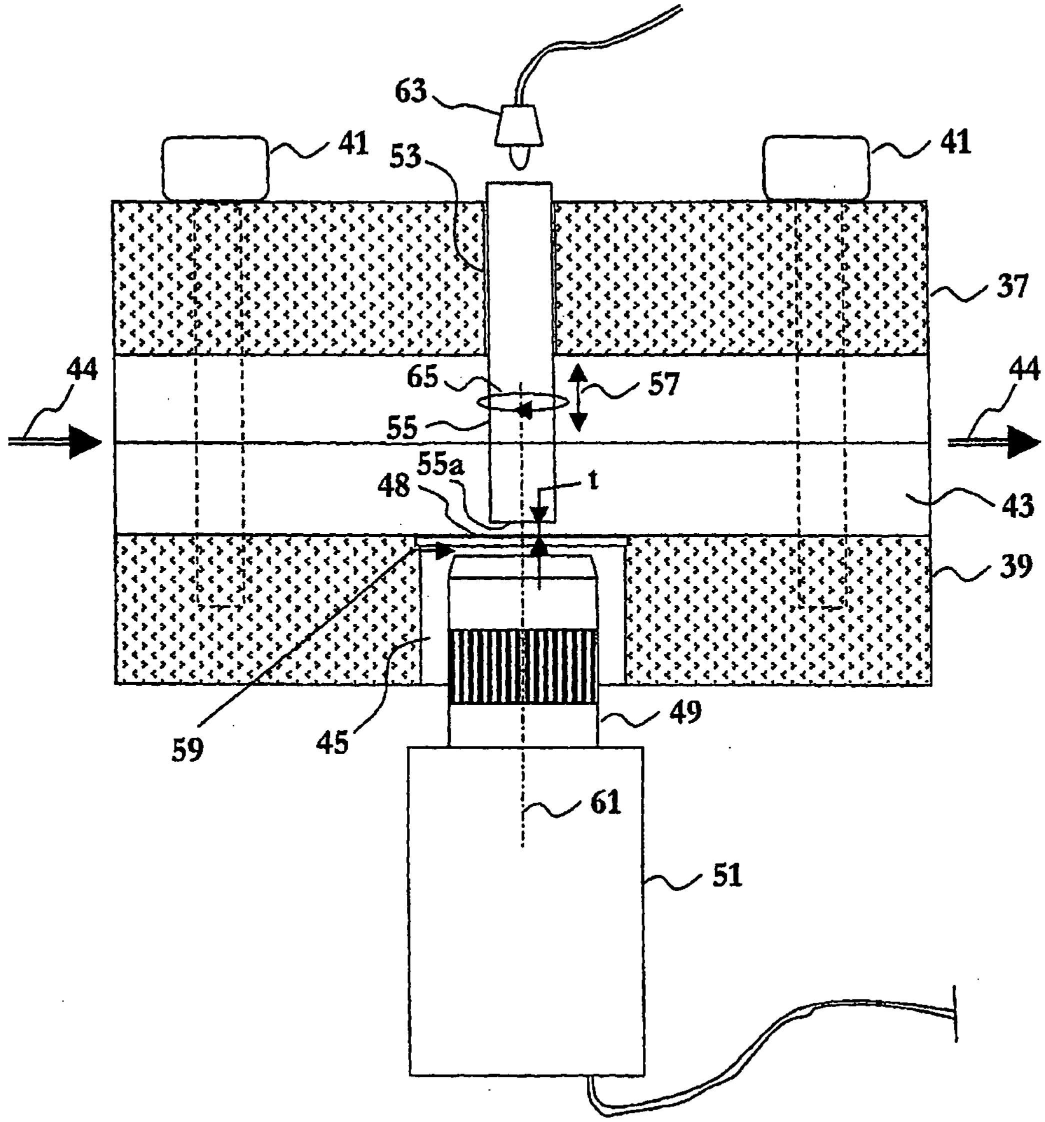

Fig. 2

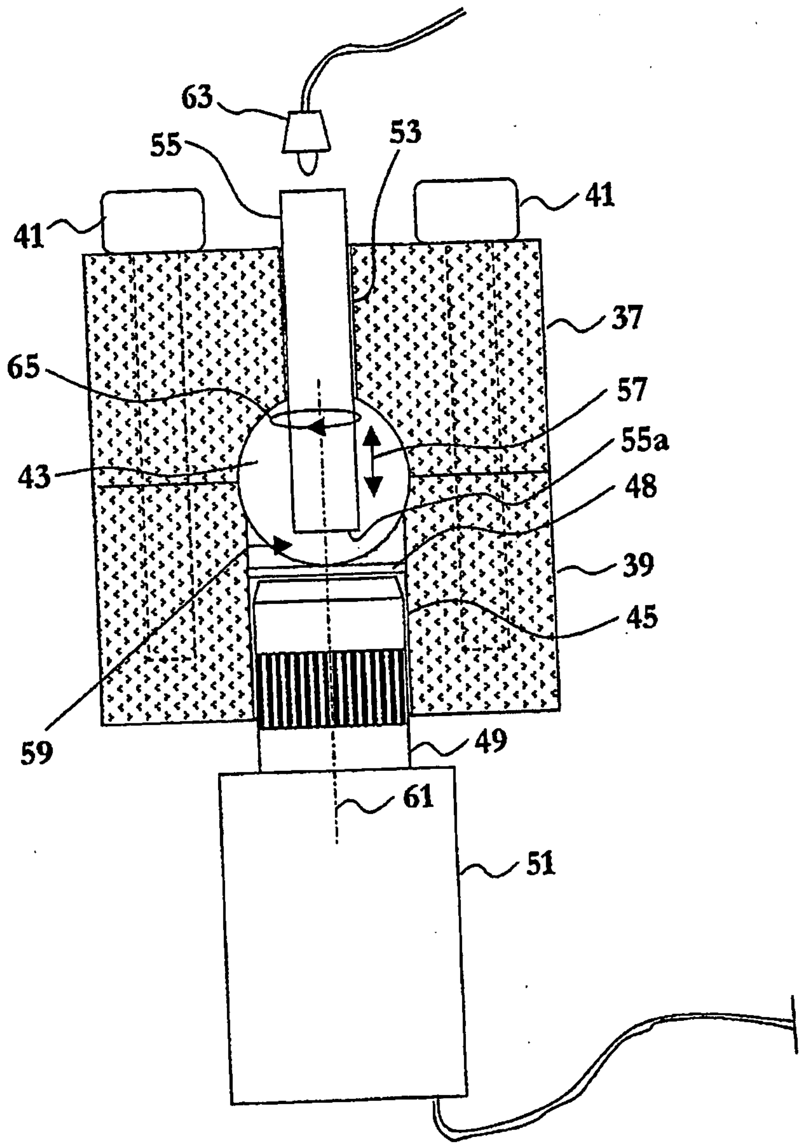

Fig. 3

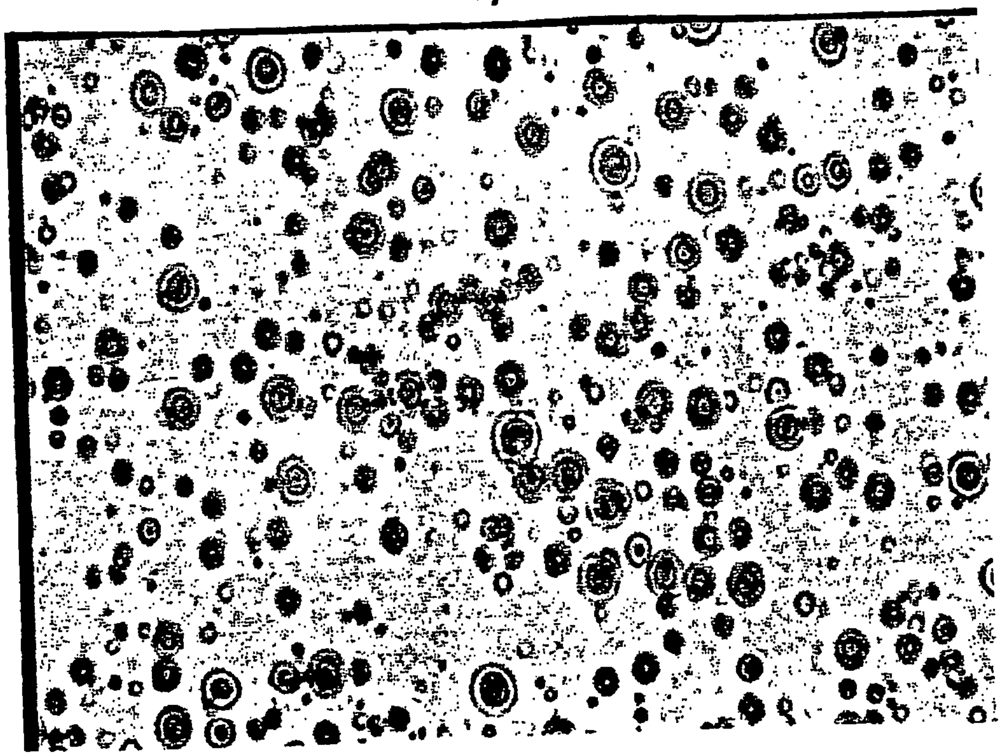

Fig. 4

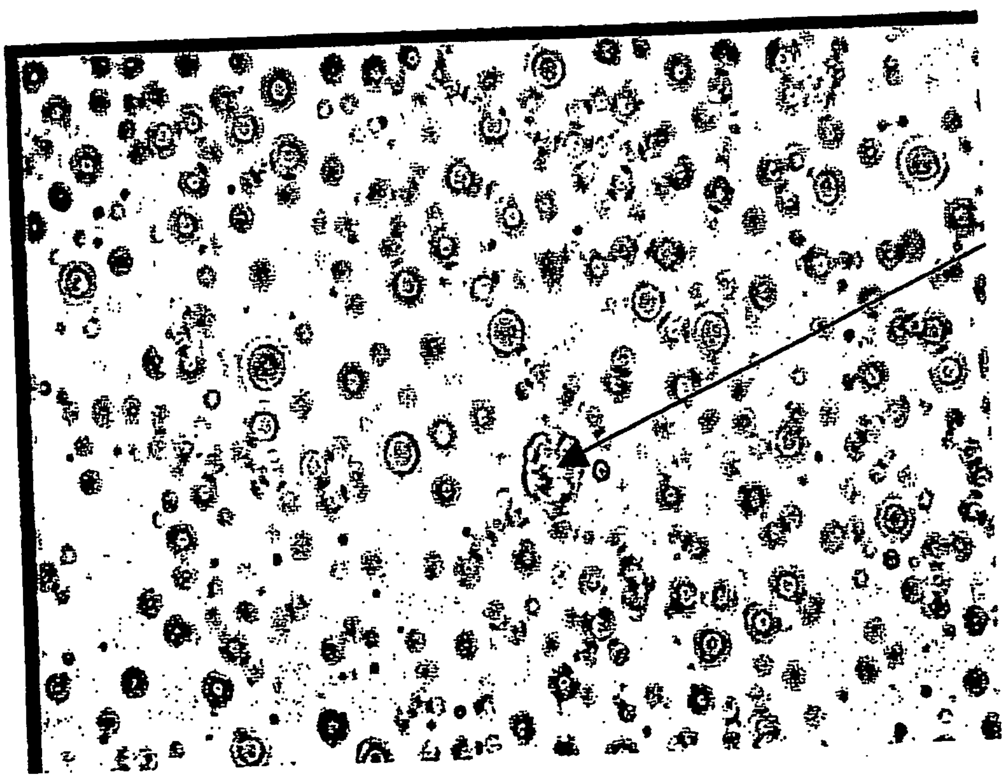

Fig. 5

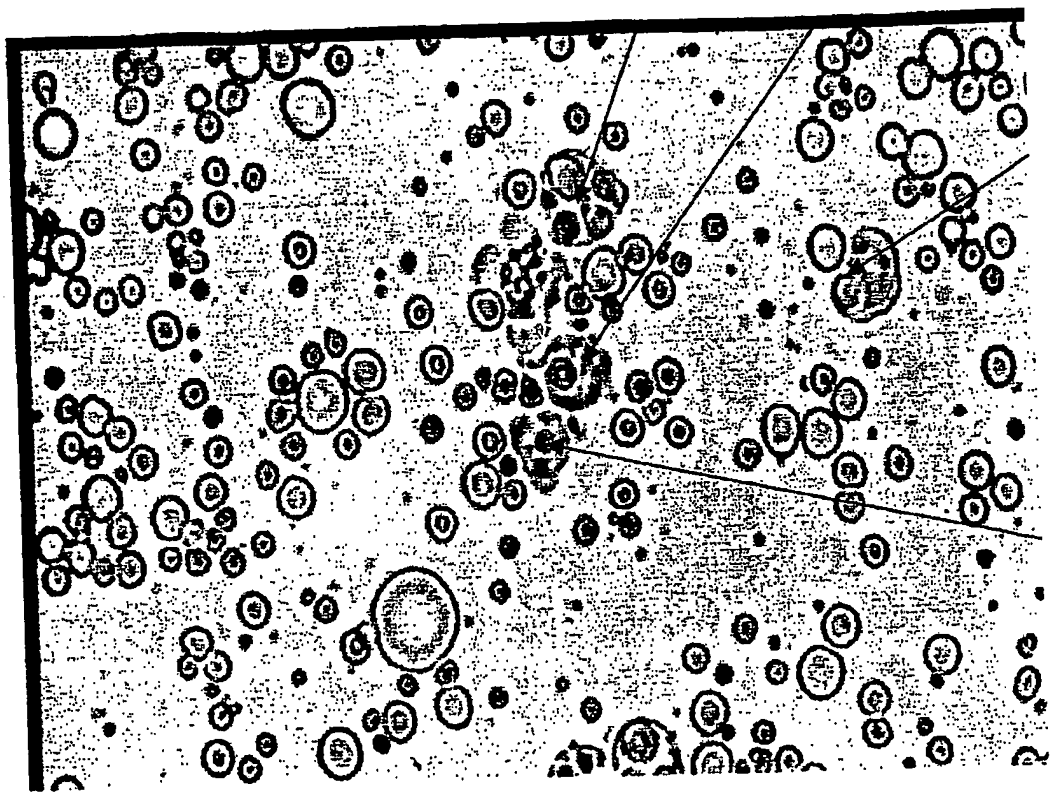

Fig. 6